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Overcoming Barriers to Nutrition Garden Adoption: A Strategic Approach using Analytical Hierarchy Process

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ABSTRACT

Background: Nutrition gardens have emerged as a sustainable solution to improve dietary diversity and address household-level food and nutrition insecurity. However, their adoption is often limited by multiple barriers such as a lack of space, time constraints, inadequate knowledge and poor access to quality seeds. In the Ludhiana district of Punjab, these constraints are particularly significant, necessitating a systematic approach to identify and prioritise effective interventions.

Methods: The study employed a multistage sampling approach to survey 214 farmers across three villages in Ludhiana district. Additionally, 50 agricultural experts were consulted to formulate and assess potential strategies. An Analytical Hierarchy Process (AHP) was used to prioritise the identified constraints and rank strategic interventions based on expert judgement and pairwise comparisons.

Result: The AHP analysis revealed that space constraints were the most critical barrier, with vertical and terrace gardening identified as the most effective strategies. Knowledge gaps ranked second, with peer-to-peer learning and educational materials emerging as key solutions. Time-saving gardening techniques and improved access to quality seeds were also prioritised, but with relatively lower weights. The consistency ratios in all comparisons were within acceptable limits, confirming the reliability of the results.

Key words: Analytical hierarchy process (AHP), Food security, Nutrition gardens, Space constraints.

INTRODUCTION

Food security is characterised as a condition where all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). In 2020, it was reported that hunger affected an estimated 720 to 811 million people worldwide (FAO *et al.,* 2021). Undernutrition is a factor in approximately three million child deaths annually, representing nearly half of all child mortality globally (Myers *et al.,* 2017). A varied diet is essential to fulfil the body's nutritional needs (Arimond and Ruel, 2004). According to Tontisirin *et al.* (2002), home gardens and small-scale livestock initiatives can be effective interventions for reducing micronutrient deficiencies by improving dietary diversity. The term kitchen gardens typically refers to food cultivated in or near the household for personal use (Evans and Jespersen, 2001). These gardens may take various forms, including mixed gardens, backyard plots, or homestead gardens. Kitchen gardening is one of the oldest and most widespread systems of food production globally (Landauer and Brazil, 1985; Rowe, 2009). Such gardens provide a sustainable source of nutrient-dense fruits and vegetables, which can enhance dietary quality and promote better health outcomes (Keding *et al.,* 2013; Bharti *et al.,* 2024). In recent times, resorting to vegetable cultivation is considered to be a highly profitable business amongst the farming community in India (Nishant and Upadhyay, 2016). Historically, kitchen gardens have served as dependable sources of food and nutrition during economic downturns and food crises (Barthel *et al.,* 2015; Warren *et al.,* 2015).

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However, despite their benefits, the implementation and adoption of these gardens face numerous barriers. Research indicates that spatial limitations, time constraints, lack of knowledge and difficulties in obtaining quality seeds are the primary factors deterring the wider adoption of nutrition gardens, particularly in urban or densely populated areas (Mitchell and Hanstad, 2004). A survey conducted to investigate these challenges revealed that the most significant barrier to adopting nutrition gardens is the lack of space followed by second and third most prevalent challenges are time constraints and insufficient knowledge. In addition, more than half of respondents indicated difficulty in obtaining quality seeds and found gardening to be labour-intensive (FAO, 2020). To address these challenges, strategies have been proposed, such as vertical and container gardening to overcome space limitations, educational programs to

bridge knowledge gaps and partnerships with seed suppliers to ensure access to high-quality seeds. A hierarchical analysis of these strategies reveals that addressing space constraints is the top priority, followed by strategies for increasing knowledge and improving seed access, with time management solutions being less critical (Saaty, 2008).

This research paper aims to examine the effectiveness of these strategies through an analytical hierarchy process (AHP) analysis, offering a data-driven approach to prioritize interventions that can enhance the adoption of nutrition gardens. By doing so, it provides a roadmap for policymakers and stakeholders to promote nutrition gardens as a *via*ble solution to food security and nutritional deficiencies in both urban and rural settings.

MATERIALS AND METHODS

The study has been conducted in Ludhiana district of Punjab (Fig 1). A multistage random sampling method was employed to select three villages from the district and all the farmers within the three villages were selected as the respondents of the study totalling to a sample of 214 farmers from 2021-22. The constraint analysis to identify the major constraints faced by the farmers were done using these respondents. The problems faced by the farmers were analysed then strategies were formulated with the help of 50 experts in the field of agriculture. The identified strategies were structured and prioritised using Analytical hierarchy process (AHP) (Fig 2).

RESULTS AND DISCUSSION

The farmers were asked to indicate the major problems that they faced while they were trying to adopt nutrition gardens. The major constraints identified were as follows (Fig 3).

The data indicates that the most significant barrier to the adoption of nutrition gardens is the lack of space, with 83.35 per cent of respondents citing this as a reason, making it the highest-ranked factor. Close behind, 77.94 per cent of respondents mentioned both the need for more time to grow and a lack of knowledge regarding nutrition gardens, ranking them as the second and third most common reasons, respectively. These findings suggest that time constraints and educational gaps are substantial hurdles to wider adoption. Additionally, 65.44 per cent of respondents reported difficulty in obtaining quality seeds, which ranked fourth, highlighting the importance of resource accessibility. Overall, the data suggests that spatial limitations, time constraints and lack of knowledge are the most pressing issues deterring people from starting nutrition gardens, with resource availability and labour intensity also playing notable roles (Vyas and Singh, 2025).

Strategies for wide-spread adoption of nutrition gardens

Strategies for lack of space

In addressing the issue of space constraints for nutritional gardens, several innovative strategies can be adopted to optimize the available area. Vertical gardening is one such approach, where vertical structures like trellises, hanging pots and stacked containers are used to grow vegetables and herbs, allowing for significant increases in plant yield with minimal ground space (Galhena *et al.,* 2013). Another effective method is the use of small-scale hydroponic systems, which allow plants to be grown in water rather than soil, thus conserving both space and water while also requiring minimal maintenance. These systems are especially beneficial for small spaces and urban environments, where traditional soil-based gardening might not be feasible (Mahaboob *et al.,* 2022). Additionally, even small backyard or balcony spaces can be transformed into productive gardens. These spaces can be utilized to grow a variety of nutrient-rich plants, providing households with essential micronutrients and improving food security (Singh *et al.,* 2018). For individuals or families with extremely limited space, community gardens present another *via*ble solution. These shared plots of land enable multiple households to grow food together, effectively overcoming individual space limitations while fostering a

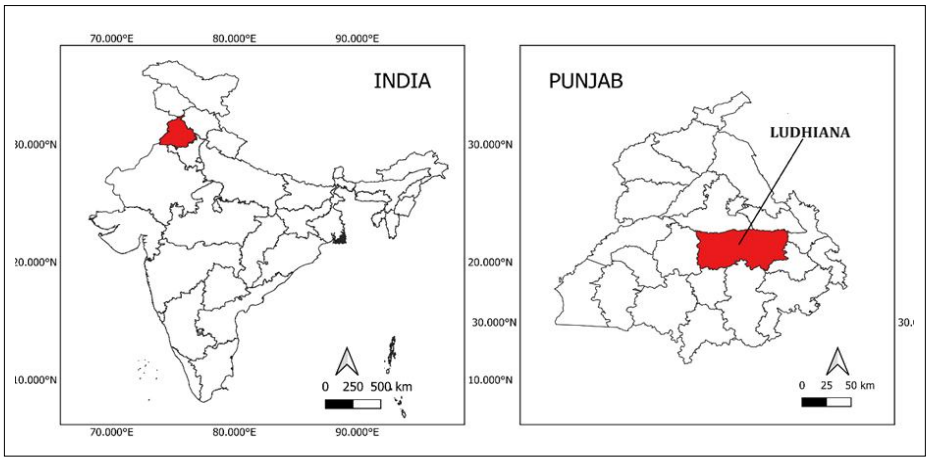


Fig 1: Locale of study.

sense of community and collective food production (Sileshi *et al.,* 2022). These approaches demonstrate the flexibility and creativity that can be applied to overcome space constraints, contributing to enhanced household food security and nutritional outcomes.

Strategies for lack of knowledge

To address the lack of knowledge about kitchen gardening among respondents, several strategies can be implemented. One effective approach is to offer structured education and training programs to fill gaps in technical understanding, such as seed treatment, irrigation and pest management. Studies highlight that lack of technical know-how is a significant barrier to adopting kitchen gardening and targeted training interventions have proven successful in enhancing knowledge and practices (Sharma *et al.,* 2011). Another approach is the use of self-learning tools, such as online resources, which provide rural households with accessible and cost-effective ways to learn kitchen gardening techniques. For instance, a self-learning CD-ROM in Sri Lanka significantly improved the respondents' understanding of the topic (Kotandeniya and Anuradha, 2013). Community-based learning, where participants engage in collective, hands-on activities, has also been shown to be beneficial, especially in marginalized communities, where group learning enhances knowledge sharing and empowerment (Ghosh and Maharjan, 2013). Additionally, combining kitchen gardening programs with nutrition education can significantly increase knowledge about dietary benefits, as demonstrated by interventions in Nepal that promoted vitamin A and iron-rich plants (Jones *et al.,* 2005). Therefore, a mix of formal training, self-learning resources, community participation and integrated nutrition education can effectively address knowledge gaps and encourage the successful adoption of kitchen gardening.

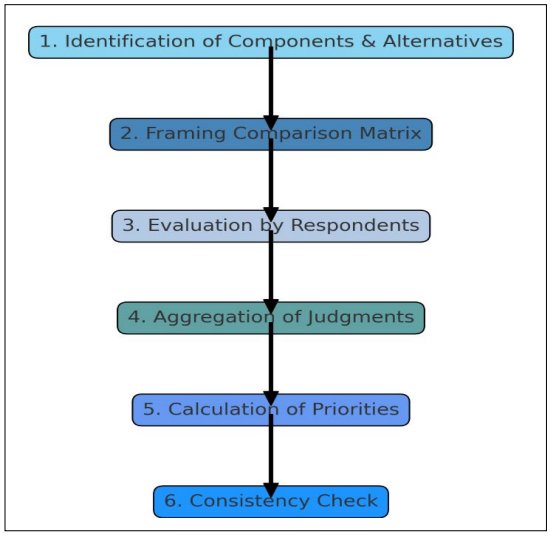


Fig 2: Procedure followed in calculation of priorities using analytical hierarchy process.

Strategies for time constraints

When respondents face time constraints in maintaining kitchen gardens, several strategies can help reduce the time commitment while still ensuring productivity. Automated gardening systems, such as those using low-cost moisture sensors, can significantly reduce the need for manual watering by automating irrigation based on soil moisture levels, which allows users to control the system remotely *via* mobile applications (Tripathy *et al.,* 2015). Similarly, smart kitchen gardening solutions that utilize real-time sensor data for monitoring soil conditions, combined with mobile-based crop management, have been shown to improve efficiency and reduce the time spent on garden maintenance (Kumar and Rufus, 2018). Another approach involves adopting low-maintenance gardening practices like integrated pest management (IPM) systems, which use cultural and biorational tactics to control pests with

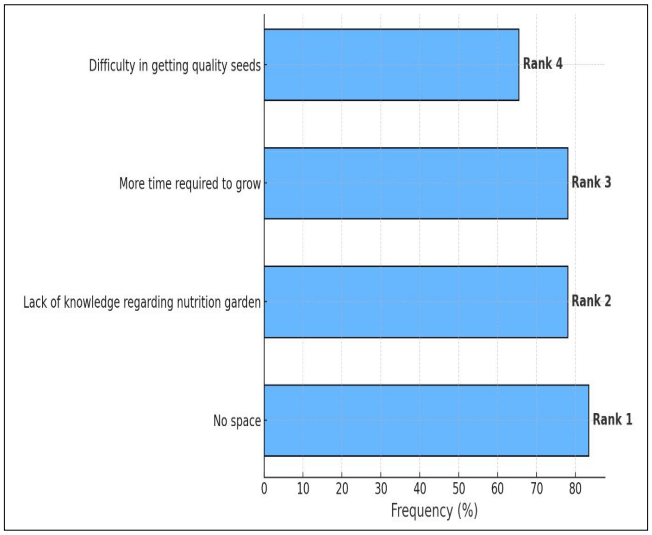


Fig 3: Constraints faced in the adoption of nutrition garden.

minimal effort. These systems can reduce the time required for pest management compared to traditional methods (Baysal *et al.,* 2009). Lastly, adopting easy-maintenance gardening techniques, such as selecting perennial plants that require less frequent care, can also help minimize the time required for garden upkeep while maintaining productivity (Medha *et al.,* 2022). These strategies collectively provide effective solutions for individuals who want to maintain kitchen gardens but have limited time available.

Strategies for getting quality seeds

To ensure access to high-quality seeds for kitchen gardens, several strategies can be adopted to improve seed selection and maintain seed quality (Fig 4). One approach involves using certified seeds, which are produced following stringent quality standards, ensuring their *via*bility and resistance to diseases, pests and environmental stresses. Certified seeds not only improve the germination rate but also lead to higher yields, making them a crucial component for successful gardening (Elias, 2018). Additionally, seed priming techniques, such as soaking seeds in solutions to initiate metabolic activity before planting, can enhance germination rates and seedling vigour, which is especially helpful in areas with adverse environmental conditions (Debbarma and Das, 2017). Another method to improve seed quality is the use of microbial treatments, where seeds are coated with beneficial microbes to promote early plant growth and increase resilience to stress factors (Cardarelli *et al.,* 2022). These strategies not only ensure high-quality seeds but also enhance the overall productivity and sustainability of kitchen gardens.

Table 1 illustrates the priority weights and consistency measures for four strategic components in an analytical hierarchy process (AHP) analysis, focusing on strategies for addressing various constraints. The strategies for lack of Space hold the highest priority with a weight of 0.546, indicating it accounts for 54.6 per cent of the overall decision-making emphasis. The strategies for lack of knowledge rank second with a priority weight of 0.256, followed by the strategies for quality seeds at 0.138 and finally, strategies for time constraints, which has the lowest priority at 0.061, reflecting its lesser significance in the overall analysis. These components exhibit strong consistency, with a λ max of 4.03, CI of 0.010 and a CR of 0.011, well below the acceptable threshold of 0.1, confirming the reliability of the comparisons.

The AHP analysis presented in the Table 2 identifies the relative importance of four key strategies for adopting nutritional gardens: Space constraints, lack of knowledge, lack of time and quality seeds, along with their respective sub-components. The results show that Strategies for Space Constraints have the highest priority, with a weight of 0.56 and a consistency ratio (CR) of 0.053, indicating high consistency in the judgments. Among the sub-components within this strategy, terrace gardening ranks as the most impactful, contributing 0.37 to the overall priority, followed closely by vertical gardening with 0.14. These sub-components rank 1st and 2nd overall, demonstrating the importance of maximizing space through innovative gardening methods. Although Community or Shared Gardens contribute less, with an overall priority of 0.05, they still hold relevance in addressing space-related challenges, ranking 5th overall.

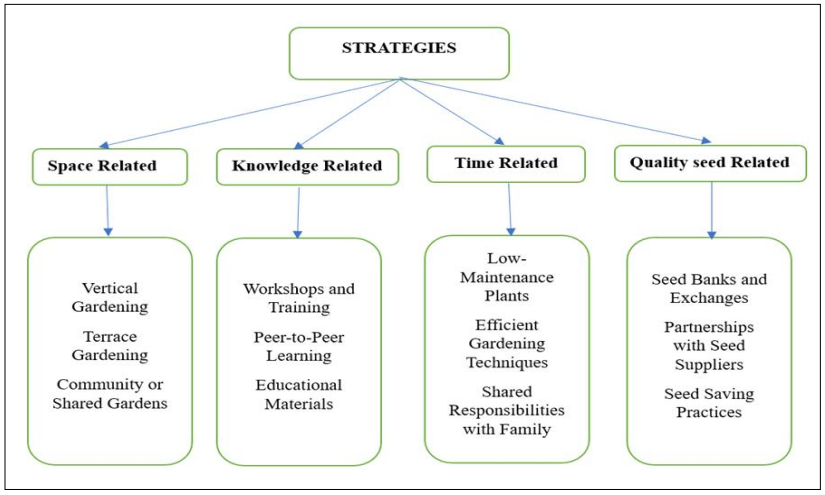


Fig 4: Problem modelling of analytical hierarchy process used in the study.

Table 1: Priority weights of the components considered for the study.

Component	Priority weight	λ max	CI	CR
Strategies for lack of space	0.546	4.03	0.010	0.011
Strategies for lack of knowledge	0.256			
Strategies for quality seeds	0.138			
Strategies for time constraints	0.061			

Table 2: Priority weights and overall ranks of alternatives considered for the study.

Component	Priority weight	λ max	Consistency index	Consistency ratio (CR)	Sub-component	Overall priority of the alternative	Overall rank
Strategies for space constraints	0.56	5.24	0.06	0.053	Vertical gardening	0.14	2
					Terrace gardening	0.37	1
					Community or shared gardens	0.05	5
Strategies for lack of knowledge	0.16	4.04	0.01	0.014	Workshops and training	0.04	11
	0.16	4.04	0.01	0.014	Peer-to-Peer learning	0.10	8
	0.16	4.04	0.01	0.014	Educational materials	0.02	3
Strategies for lack of time	0.14	4.02	0.01	0.006	Low-maintenance plants	0.04	7
	0.14	4.02	0.01	0.006	Efficient gardening techniques	0.06	4
	0.14	4.02	0.01	0.006	Shared responsibilities with family	0.03	10
Strategies for quality seeds	0.14	3.04	0.02	0.037	Seed banks and exchanges	0.04	12
	0.14	3.04	0.02	0.037	Partnerships with seed suppliers	0.06	9
	0.14	3.04	0.02	0.037	Seed saving practices	0.03	6

The second most critical strategy is strategies for lack of knowledge, with a priority weight of 0.16 and a CR of 0.014, again showing reliable consistency in the pairwise comparisons. Peer-to-Peer Learning emerges as the most effective sub-component within this strategy, with a priority of 0.10, ranking 8th overall, underscoring the value of experiential learning and community-based knowledge exchange. Workshops and training, despite being a traditional knowledge-sharing method, contribute less to the overall priority, ranking 11th, while educational materials rank 3rd, indicating that while peer-based learning is favoured, structured educational resources still play a significant role in knowledge dissemination. The strategies for lack of time, with a priority of 0.14 and an excellent CR of 0.006, emphasize efficient gardening techniques as the most important time-management solution, contributing 0.06 and ranking 4th overall, followed by Low-Maintenance Plants, which rank 7th.

Lastly, strategies for quality seeds, with a priority weight of 0.14 and a CR of 0.037, highlight Partnerships with Seed Suppliers as the most effective approach, contributing 0.06 to the overall priority and ranking 9th. Interestingly, despite their perceived importance, seed banks and Exchanges rank lowest at 12th, suggesting a shift towards more dynamic and collaborative seed acquisition methods.

CONCLUSION

This study underscores the transformative potential of nutrition gardens in addressing food security and nutritional deficiencies, especially in resource-limited urban and rural settings. Using the analytical hierarchy process (AHP), space constraints emerged as the most significant barrier, followed by knowledge gaps, seed access issues and time limitations. Innovative strategies such as terrace and vertical gardening, peer-to-peer learning and educational materials were identified as key enablers to overcome these challenges. Although time and seed access were lower in priority, interventions like efficient gardening techniques and partnerships with seed suppliers remain important for feasibility. The findings offer a clear, evidence-based roadmap for policymakers to promote nutrition gardens through space-optimising techniques, structured training, improved seed distribution systems and community engagement initiatives-thereby supporting food security, sustainability and public health.

Conflict of interest

The authors report no conflict of interest.

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